

Telerobotic/Autonomous Control using Control Shell

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The Mixed Waste Management Facility (MWMF) at the Lawrence Livermore National Laboratory (LLNL) was designed as an integrated pilot-scale facility to bridge the gap between mature, bench-scale proven technologies and full-scale treatment facilities. As an integrated facility, technologies are being demonstrated to cover the entire treatment train from waste receipt to output of the final waste form and effluents. Telerobotics was chosen for deployment in MWMF for container handling, waste characterization and preliminary sorting in the front-end. Alternatives that were evaluated included manual operations — which was retained for back-up operations but determined unacceptable for wide-spread use across the complex due to waste hazards and its associated waste generation. Standard teleoperation was rejected for productivity concerns and robotic or fully automated approaches were deemed too technically risky at this point.

Once telerobotics was chosen for deployment, the Telerobotic Demonstration System design team had the task of taking bench scale systems and improving their reliability and robustness, integrating a variety of technologies that had not been used together before, and developing a design that met waste handling needs in an efficient and cost effective manner. The project was funded through the Office of Waste Management (EM-30) and there was little interest in funding another “R&D” project — the focus was on delivering a working system.

Lawrence Livermore National Laboratory pulled from prior and ongoing work in telerobotics, autonomous grasping and image processing funded through EM-50 at LLNL and related telerobotics work at ORNL to serve as a basis for a tele-robotic and autonomous controller architecture for waste handling and sorting. As a starting point, prior work was restructured and ported to a ControlShell environment (by Real Time Innovations). Significant improvements in the collision avoidance, force compliance and shared control aspects were then developed. Several orders of magnitude improvement were made in some areas to meet the speed and robustness requirements of the application.

The resulting controller architecture and functionality supports the following behaviors:

- master position to tele-robotic position control
- master position to robot velocity control
- force compliant tele-robotic control
- real time collision avoidance
- autonomous motion control
- operator force queuing
- operator selectable tele-robotic behaviors

The control system is currently being used to integrate and control a Schilling Titan III manipulator and a Cybernet force reflecting master controller in a plant-prototypic waste sorting demonstration cell. The system has been in use for several months and is currently being tested by operators with little or no robotics background and essentially no training. This paper discusses, in more detail, the telerobotic controller architecture and the system results to date.

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